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IREAPS

A CNC SHEETMETAL FABRICATION SYSTEM FOR PRODUCTION OF SHIPS VENTILATION COMPONENTS AND FLATWORK

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ABSTRACT

The U. S. Navy has a need to produce more ships at lower cost. As documented by a recent study , present shipyard methods for fabricating ventilation and flatwork are key cost drives in ship production. They consist of a multitude of repetitious operations, resulting in excessive manhours and material costs.

By utilizing computer graphics technology and Computer Numeric Control (CNC) machine tools, it is possible to reduce the manhours required for fabrication of ventilation and flatwork by as much as 40 percent. Benefits resulting from increased efficiency in materials use, in-process storage and production planning may also be realized by users. In addition, the U. S. Navy can benefit through a reduction in ship production costs, increased production capacity and spread of a new technology adaptable to many shipyards.

This paper discusses a joint effort by the Naval Ship Systems Engineering Station (NAVSSES) and the Bath Iron Works Corporation (BIW) to develop and implement a Computer-Aided Manufacturing (CAM) system for cutting the cost of fabricating ventilation and flatwork in BIW sheetmetal operation. It is a cost-shared project, funded by the Navy under its Manufacturing Technology (MAN TECH) program.

Key topics presented will be: Sheetmetal Fabrication Process at BIW; CNC Sheetmetal Fabrication System Configuration; System Advantages, and Implementation Factors for follow-on users.

1.0 INTRODUCTION .

In 1976-77, the U. S. Navy Manufacturing Technology (MAN TECH) Program Office conducted a study to identify key operations in Naval ship construction where new approaches to production could be developed and which could reduce costs and make more efficient use of U. S. shipyards capacity. This study identified the sheetmetal fabrication operation as a high cost driver within BIW. Further investigations conducted by NAVSSES confirmed this as a cost driver throughout U. S. shipbuilding. Consequently, based on a proposal from BIW, NAVSSES initiated the CNC Sheetmetal Fabrication System Project to develop a promising new approach to sheetmetal fabrication.

The vehicle used to fund this project is the Department of the Navy's Manufacturing Technology (MAN TECH) program. MAN TECH's basic objective is to improve the productivity and responsiveness of the defense industrial base. This is accomplished through projects which demonstrate specific applications of new and improved manufacturing technologies. Concepts, whose feasibility has already been shown in R&D, are often transferred and developed by industry in a proof-of-application effort. The application and benefits are then documented for use by the Navy and industry at large.

The CNC Sheetmetal Fabrication System is one such project. It was funded in 1979 and is well underway, with all of the hardware and much of the software in place at BIW. The current schedule will see system proveout completed by December 1981 with full documentation to follow.

The system integrates a Numerical Control Support System (NCSS) with a Direct Numerical Controlled (DNC) Sheetmetal Fabrication Center (SFC), which, together, automate that portion of the sheetmetal fabrication process which begins with the lofting operations and ends with the finished two dimensional component parts.

This paper starts with a description of current sheetmetal operations at BIW and describes the new system being developed which will automate these current operations. A discussion of the anticipated benefits for the Navy, BIW and follow-on users will also be presented.

2.0 SHEETMETAL FABRICATION PROCESS AT BIW

Shipboard sheetmetal products fabricated at BIW consist primarily of ventilation ductwork and of flatwork. Ventilation ductwork consists of a variety of components, the majority of which fall into a few generic shapes (ie: elbows, straights, transitions, reducers, twists and tees). Flatwork refers to all other products fabricated from steel material with maximum thickness of 1/4 inch (ie: gage boards, power panels, bulkhead curtain plates, electrical enclosure curtain plates and crew's lockers and berths).

Figure 1 diagramatically depicts the current fabrication process used at BIW for both ventilation and flatwork. Note that the process initiates with a pre-existant ship's plan or engineering drawing from which a specific ventilation or flatwork shape will be defined as a "part". Templates for each part - for example, a centered rectangular to round transition or an under-deck curtain plate -- are then manufactured during the manual lofting stage. In the case of a ventilation shape, this lofting operation also involves breaking the three dimensional ventilation part into an equivalent, properly scaled, two dimensional flat pattern. Then each flat pattern is further broken down into several individual pieces, which we, in the project, refer to as "piece-marks". Finally, a template for each piece-mark must be manufactured. Therefore, a multitude of templates, one for each piece mark, must be manufactured during lofting for a single ventilation part. After the lofting operation, each template is laid out by hand and scribed into sheet-metal stock. The stock is then rough sheared and the piece-mark or flatwork part is cut out and hand trimmed to final dimensions. If an access hole is required, this will be done next on a manual punch machine. The pieces are then identified and either stored as is, or assembled for immediate installation as finished parts.

As described, this process requires highly specialized labor skills to perform excessively repetitious, time consuming manual operation. The process is therefore easily recognized as labor intensive. Bulk storage of the valuable, reuseable templates is required, and this results in dedication of floor space which could be better used for manufacturing. This process also fosters an undesirable situation in which the sheetmetal shop must fabricate three to four complete ship sets of ventilation material ahead of the individual hull erection schedule.

3.0 CNC SHEETMETAL FABRICATION SYSTEM

The development of the CNC Sheetmetal Fabrication System is conceived as a viable, timely solution for the high cost of manufacturing ventilation and flatwork at BIW. It has also been acknowledged as a potential solution to similar costs drivers at other U. S. shipyards by the Society of Naval and Architectural Marine Engineers (SNAME) .

This system incorporates two modern technologies: Interactive Graphics and Direct Numerical Control of production machinery. The system itself is made up of two computer based modules: the Numeric Control Support System (NCSS) and the Sheetmetal Fabrication Center (SFC). Figure 2 is a diagrammatic comparison of the forthcoming new ventilation and flatwork production process versus the current process previously described. As shown, the NCSS module will replace the current manual lofting and manual layout operations; and, the SFC will replace the rough shearing, finish trimming and hole punching operations.

As presently conceived, these modules will be located in separate areas and will be linked by a "soft" medium, ie the "Job Diskette". This'job diskette will contain all the parts definition and management data generated by the NCSS. This is the data which must be communicated to the SFC for fabrication of ventilation piece-marks and flatwork parts. Figure 3 is a schematic drawing showing the hardware layout for each of the two modules. Note the dashed line connecting the two modules. This represents the "soft" link.

3.1 THE NUMERICAL CONTROL SUPPORT SYSTEM (NCSS)

The NCSS will be located in BIW's computer operations room and consists of a computer, highspeed printer/plotter, a graphics display terminal, a high speed magnetic tape drive, a dual floppy diskette drive and a cartridge module disk unit.

The function of the NCSS is to (1) interactively (person/computer) develop ventilation and flatwork parts production data and (2) automatically generate material management information, parts management information, production management reports and Numerical Control (NC) machinery control data.. The system software will handle ventilation parts and flatwork parts separately and each in a very unique manner. BIW has developed a geometric set of twenty-nine standard ventilation shapes. This set is being programmed as a hardware independent software package and developed solely for the definition and production of standard ventilation shapes. We have estimated that in excess of 90% of all geometric requirements for ventilation parts will be covered by this set of standard ventilation shapes., All one-of-a-kind ventilation parts and all flatwork parts will be produced using a commerically available interactive graphics software package.

3.2 THE SHEETMETAL FABRICATION CENTER (SFC)

The SFC will be located in the sheetmetal shop and consists of a computer, a dual floopy diskette drive, an auxiliary data entry console and a commericial turret punch press with plasma cutting capability. Control data generated by the NGSS will be input into the SFC via the job diskette for the actual cutting or fabrication of both ventilation piece-marks and flatwork parts.

3.3 CNC SHEETMETAL FABRICATION SYSTEM OPERATION (CNS-SMFS)

The previous sections discussed the NCSS and SFC as separate modules which, when integrated, comprise the entire CNC Sheetmetal Fabrication System (CNC-SMFS). It was noted that this integrated system handles standard ventilation shapes and flatwork parts differently. This is shown in Figure 4. Note that the interactive graphics software package for flatwork (and one-of-a-kind ventilation parts)- is shown here as a CAD/CAM System. This part of the CNC-SMFS is conceived as user-specified, and therefore, will not be described further. The software for standard ventilation shapes is being developed under the project. The following discussion of the system operation will, therefore, center on the production of a standard ventilation shapes (the example will be a centered rectangular to round transition).

The CNC-SMFS is a menu driven system as depicted in Figure 4. The system requires two operators: the first operator will work out of the computer operations room and the second will work out of the sheetmetal shop. The first operator will refer to the engineering drawing and identify specific generic shapes that will be required for a single production run.. He will then call to a particular entry in the "shapes menu" displayed on the graphics display terminal. The CNS-SMFS will respond by displaying a three dimensional line drawing of the selected shape. Assuming the operator has selected shape number 12, a rectangular to round transition will be displayed as shown in Figure 5. The CNC-SMFS will then prompt the operator to input identification information,, material data, dimensional data and air flow direction. After the operator has verified all the data, the CNC-SMFS will display the properly dimensioned and scaled piece-marks. This display is, therefore, the 2-dimensional flatpattern equivalent of the specific 3-dimensional ventilation part defined. For shape number twelve, there will be two separate piece-marks, A and B, in the flatpattern, as shown in Figure 6. The operator now has the option of including a variety of access holes, if required. Figure 6 shows the inclusion of a round access hole in piece-mark B. At this point, the operator has uniquely defined a specific ventilation part and may either return to the shapes menu to define a new part or initiate the nesting routine. If the operator has completed definition of all the parts for a production run, he will then begin nesting the individual piece-marks. Nesting is performed interactively as shown in Figure 7. The CNC-SMFS will call up each piece-mark in succession and the operator will either nest the part on a sized sheet on the screen or move onto the next piece-mark. When all nests for a production run are completed and verified, the CNC-SMFS will automatically process all the data and create a job diskette. This job diskette will include the post-processed NC data for driving the turret punch press, as well as the following reports:

-Components list	-Nest drawings
-Material list	-Labels
-Shear list	-Tooling list
-Operator's listing	-NC listing

The job diskette, along with the operator's listing, nest drawings and labels are transferred to the second operator in the sheetmetal shop. This operator will then load the diskette into the CNC-SMFS's DNC link, place the proper material on the turret punch press and input a start command. After the CNC-SMFS has cut a duplicate of the nested drawing in the sheetmetal stock, the operator will affix labels to each piece-mark or flatwork part. The CNC-SMFS will control all cutting operations and leave small tabs between the cuts. These tabs enable the operator to off-load an entire finished nest intact. This completes the operation of the CNC Sheetmetal Fabrication System.

4.0- SYSTEM ADVANTAGES

The primary advantage of this system is a reduction in current labor costs in the production of shipboard ventilation and flatwork. BIW estimates an overall labor manhour reduction of approximately 40%.

This is the net of the following percentage savings for specific operations and the moderate additional requirements for the newly added operations:

Operations	Estimated Savings (% of Current Hours)
Shearing	75
Layout	75
Punching	
Material Handling	20
Lofting	100
Special Fittings	25
Clerical	10

Additional benefits can be grouped as:

- -materials use
- -in-process storage
- -production planning
- work throughput

Three materials-use benefits are anticipated. Computer nesting is expected to result in less generated scrap through closer nesting then typical with manual layout. The CNC-SMFS also allows common border locations for nested piece-marks and flatwork parts. The other materials use benefit concerns the increase in sheetmetal fabrication shop responsiveness. The system will be able to produce work on a more responsive basis by reducing the current long lead times in ship construction schedules.

In-process storage needs will be eliminated entirely for templates. A reduction in in-process storage of finished parts will also result from the decrease in ventilation production lead times.

Production planning will become wore flexible and work throughout will increase since the impact of engineering changes will only result in paper changes and will not be realized in material waste.

For the Navy, benefits are accrued in two major ways. Both center around the opportunity for use of this new system concept, not only by BIW, but by other shipyards. First, the ship production cost is reduced through a reduction in production cost for ventilation parts and flatwork. This has the potential to result in a lower ship procurement cost for the Navy. Secondly, the potential for increased sheetmetal production capacity may add to the capacity of the industrial base.

5.0 CONSIDERATIONS FOR FOLLOW-ON USERS

The above benefits will make permanent system use at BIW attractive. While the situations at other yards will vary, it is possible that the system can prove similarly attractive for follow-on users.

Several key points related to follow-on use are worth raising. First, the CNC-SMFS software is portable for use with other hardware. The programming of standard ventilation shapes, in particular, is seen as an important advance.

Full documentation on the system will be available through the Navy when the project is completed. This will include source documentation on the standard ventilation shapes programs and notes on portability for follow-on users.

Finally, both the Navy and BIW will be pleased to discuss and demonstrate the experience gained in this project. An integral part of MAN TECH projects is the dissemination of information to industry to help increase the application of valuable projects. The experience to date in this project indicates that its value is high and that, from the Navy's standpoint, additional application of this technology and system concept is desirable..

REFERENCES

(1) "High Cost Areas of Ship Construction", prepared by Automation Industries VITRO LABORATORIES, DIV. under Navy Contract No. N00024-74-C-7108 Task No. 745, 14 Aug 1978.

(2) Letter from SNAME, Mr. E. L. Peterson, to the Department of the Navy dated March 4, 1980.

FIGURE 1

CURRENT FABRICATION PROCESS

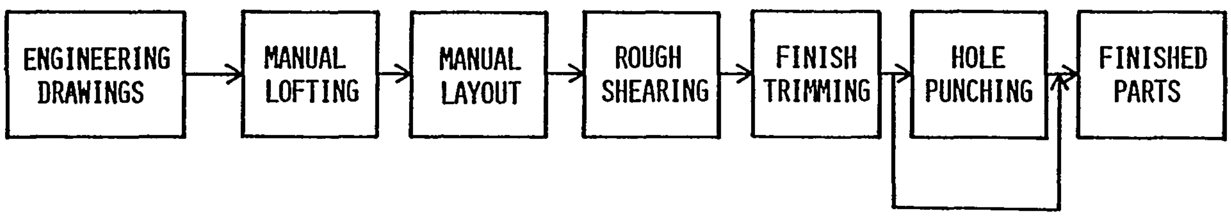
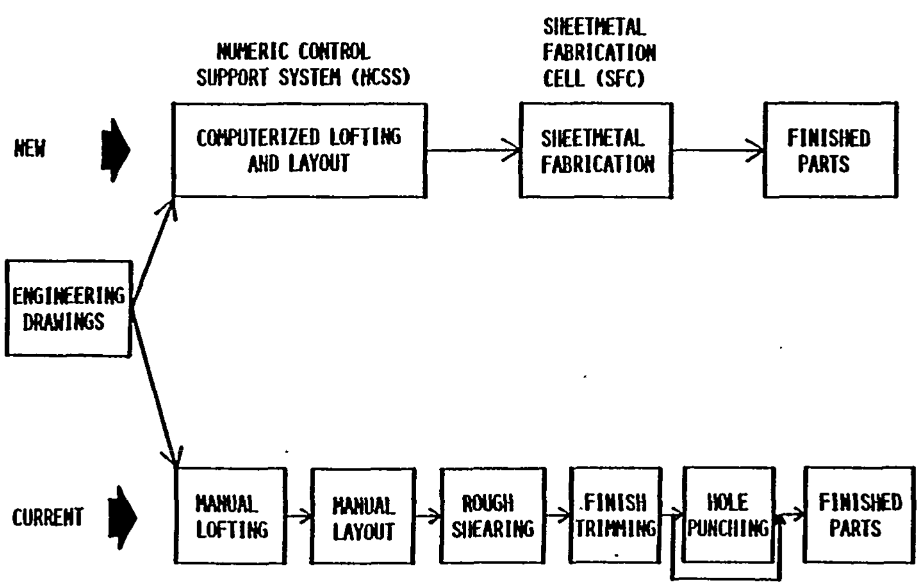


FIGURE 2

SHEETMETAL FABRICATION: NEW vs. CURRENT



HARDWARE LAYOUT

CNC SHEETMETAL FABRICATION SYSTEM

FIGURE 3

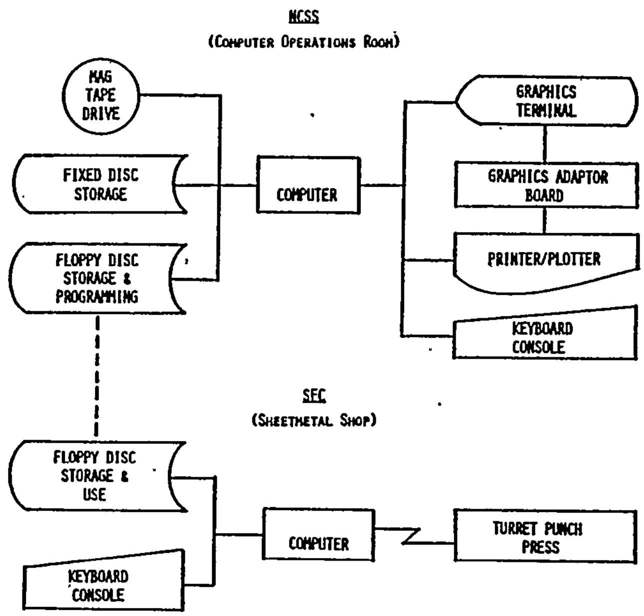


FIGURE 4

NEW SYSTEM

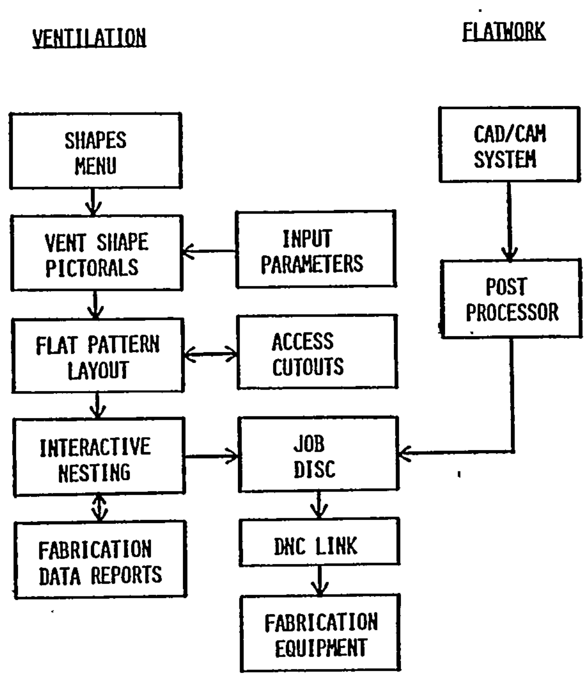


FIGURE 5
INTERACTIVE STANDARD SHAPES DISPLAY

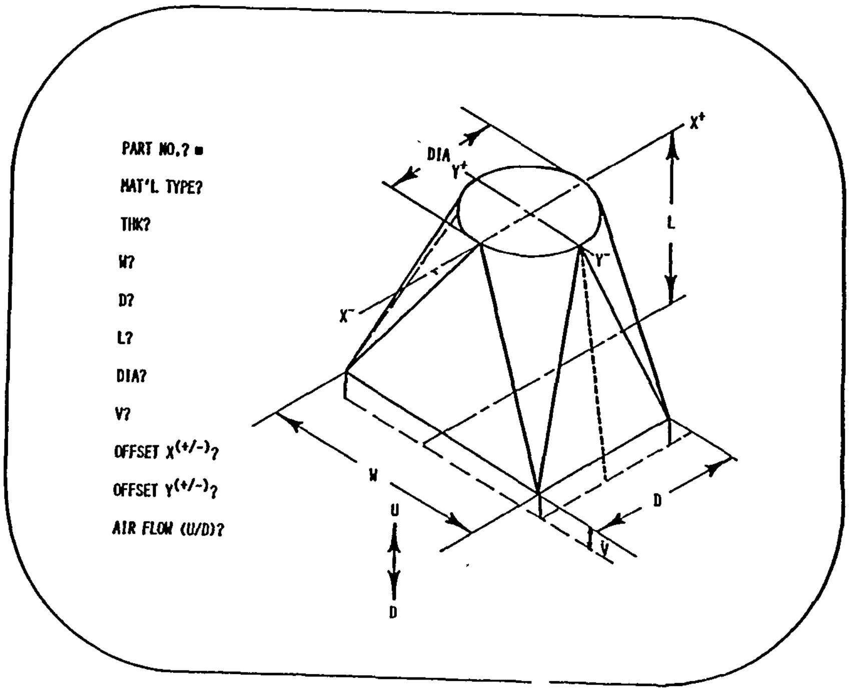


FIGURE 6
FLAT PATTERN LAYOUT

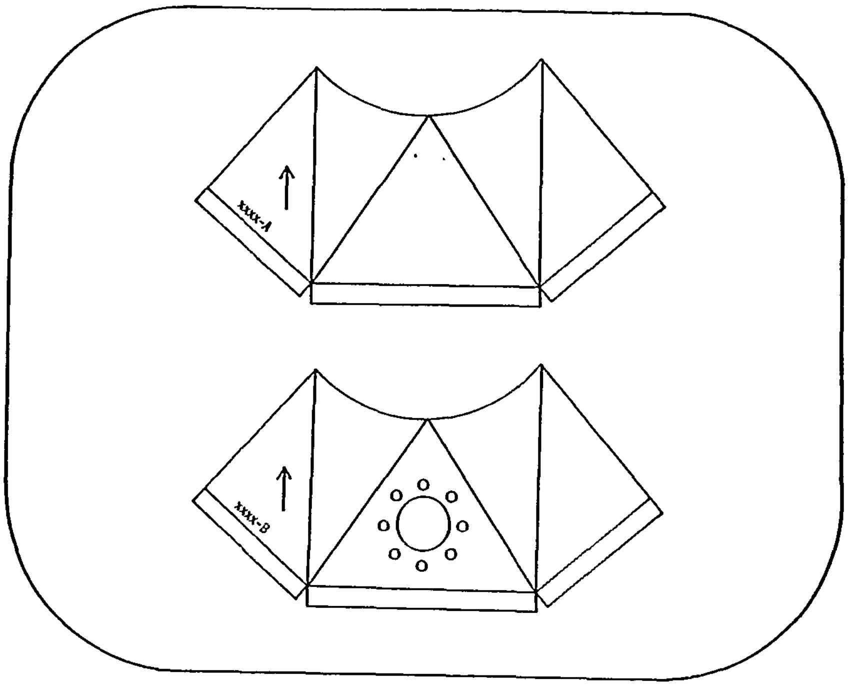
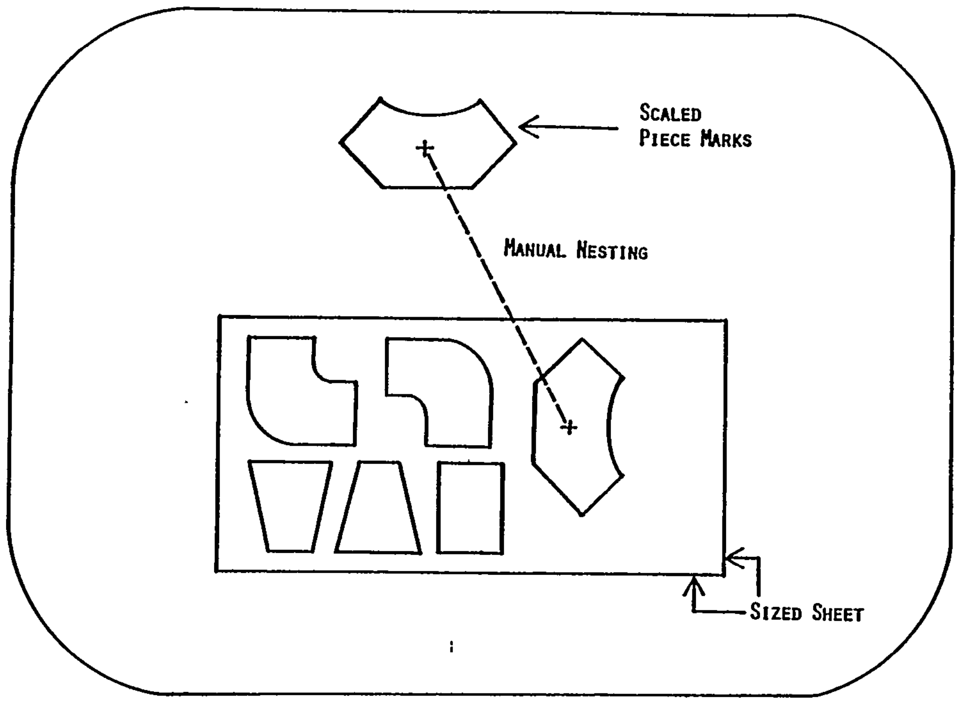


FIGURE 7
COMPUTER-AIDED NESTING



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